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ABSTRACT

This project consisted of an analysis of United States' data collected during the Second IEA Science Study (SISS). It focused on the differences in achievement scores between female and male participants at Grades 5, 9, 10, 11, and 12. A manipulative process test, as well as the written achievement test, was administered to students in grades 5 and 9. The major findings can be summarized as follows: (1) sex differences were found at every grade level and in every subject area in the written science achievement tests (this sex difference always favored males); (2) the fact that some female students have female science teachers did not appear to increase their level of achievement in all content areas (in some cases, having a female teacher had a negative relationship with science achievement for girls, while in biology, having a female teacher had a positive relationship for both girls and boys); (3) there appeared to be no sex difference in the results of the manipulative tests of process skills which were administered to both fifth and ninth-grade students. The discussion includes comparisons of the United States' findings with 17 other countries. The paper recommends the use of process oriented learning tasks for sex equity in science teaching. (CW)

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SEX DIFFERENCES IN THE SECOND IEA SCIENCE STUDY---

U.S. RESULTS IN AN INTERNATIONAL CONTEXT

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Introduction

In analyzing data collected during the Second IEA Science Study (SISS) in the U.S., a few important issues have come to light. The first and most obvious is that sex differences have been found at every grade level and in every subject area in the written science achievement tests. This sex difference always favored males. Secondly, the fact that some female students had female science teachers did not appear to increase their level of achievement in all content areas. In some populations, having a female teacher had a negative relationship with science achievement for girls, while in biology, having a female teacher had a positive relationship for both girls and boys. Third, we do have some more optimistic news. It would seem that there is little sex difference to be found in the results of the manipulative tests of process skills which were administered to both fifth and ninth grade students. Finally, data from seventeen other participating countries have been made available, allowing us to view the U.S. results in an international context.

With the Second IEA Science Study, we had hoped to find a smaller difference between the sexes in science achievement than had been found in the first study (Comber & Keeves, 1973; Wolf, 1977). The reasoning behind this hypothesis was that not only had 13 years gone by, but also that those years saw the rise of the Feminist Movement, and saw many wives and mothers forced to become working wives and mothers. The idea that girls "get through" school only to marry and raise a family has changed dramatically, and it has become an economic necessity for many families to have both spouses earning an income. In an age of science and technology, therefore, it was assumed that a proportionate number of females would be seeking education and employment in the areas of expanding opportunities. It was hoped that, realizing this growing trend, schools would become more effective in educating girls in science. Apparently, this has not been the case, the sex difference in science achievement remains about the same.

Sample Populations

Nine populations were tested by SISS. The youngest group was fifth grade students. No students were tested at Grades 6, 7, or 8, but samples were tested at each grade from ninth through twelfth. These secondary school students were selected from both first-year and advanced science classes, as well as from twelfth graders who were not taking any science courses at the time of testing. Table 1 lists the number of students each sample population.

Results of the Survey

Sex Differences in Achievement

Although some previous studies have found no significant difference between girls and boys at Grade 5, in the IEA survey we found a difference of 5.3%. At the ninth grade level, where many studies have found sex differences in science achievement to become more noticeable, we found an increase of only 1% from the fifth grade level, making the difference 6.3%. This increase was not considered to be significant (using a 2% criterion). The literature is divided in reporting sex differences at higher grade levels. Some find that the differences peak at the junior high level, than decrease through high school (Vestin, 1975; Steinkamp & Maehr, 1984). Other studies report a continuing widening of the "gender gap" all through high school (Backman, 1972; Keeves, 1973; Haertel et al., 1981; Zerega et al., 1986).

For the non-science population in our survey, the gap did shrink to only 3.7% at Grade 12. For the science populations, however, the outcomes varied. The smallest sex difference was found in first-year biology (3.0%), which helps it retain its notoriety as a "feminine" science. The difference in achievement for both first-year chemistry and physics was slightly greater (5.4%), but still in the same range as the fifth and ninth grade differences.

For second-year, or advanced science, the sex differences increased by approximately 2% in each subject area, with biology remaining the subject with the smallest difference between sexes. Overall sex differences remain fairly constant, in the 5%-7% range, with the exceptions of the Biology 1 and Grade 12 (non-science) populations which were lower. Table 2 gives the achievement test scores for girls and boys in each population tested.

Teachers as Role Models

We were curious to find whether female teachers played the part of positive role models to girls in science. At the fifth grade level, teacher sex had no significant influence on student achievement. At the ninth grade level, male teachers seemed to have a more positive influence on student achievement than did female teachers. Both girls and boys scored higher in the biology achievement tests if they had a female teacher. In advanced chemistry and in first-year physics, male teachers had a more positive influence on achievement for students of both sexes. No significant difference was found

for students in first-year chemistry, and there were too few female teachers in advanced physics to make any generalizations. Table 3 shows the scores of girls and boys in each population categorized by teacher sex.

Background variables, such as years of education and length of teaching experience, of the teachers involved in the study were analyzed to determine if there were any consistent differences between female and male teachers. The only significant difference ($t=2.25$, $p<0.05$) in prior education between males and females was found in the Biology 1 group. Females had a mean of 5.2 years of college while males had a mean of 5.5 years. Male Biology 1 teachers were also more likely to teach subjects other than biology ($t=2.90$, $p<0.005$). Teachers were asked about affiliations with science or science education associations. In the ninth grade group ($t=2.76$, $p<0.01$) and the Biology 2 group ($t=3.72$, $p<0.001$), females were more likely than males to belong to these organizations. In Biology 2, females also reported reading science journals more often than did their male counterparts ($t=2.16$, $p<0.05$). These findings agree with those reported by Welch and Lawrenz (1982). They felt that females who enter the "male domain" of science may be anxious to observe the expected behavior (i.e.-attend professional meetings, subscribe to journals, belong to professional associations) to find out how they "should" be acting.

Female teachers in Chemistry 1 were about five years older ($t=2.94$, $p<0.005$) than male teachers, 46.5 years and 41.1 years, respectively. Females were also more likely to be certified to teach chemistry ($t=2.17$, $p<0.05$), while males were more likely to teach outside of their certification ($t=2.32$, $p<0.05$). Only one difference was found between female and male teachers in physics. Males had higher gross salaries than did females, $22,870 per annum compared to $18,240 ($t=4.90$, $p<0.001$).

Perhaps the most interesting finding of the analysis was that there was so little difference reported in either teacher background or teaching methods. It was hoped that we would find an explanation for the differential student achievement in the different subject areas by finding differential teacher training or experience. This was not as clear-cut as we had expected. It has been reported that teacher attitudes greatly influence student attitudes (Baumel & Berger, 1965; Aiken & Aiken, 1969; Simpson, 1978; Kahle, Matyas, & Cho, 1985), and this must certainly be taken into account. Hoffmann (1987) has found that the students' perceptions of the climate of instruction is significantly related to interest in the subject and also to self-concept. In her study, students of both sexes had greater interest levels and higher self-concepts if they felt

comfortable in the lessons, felt that the teacher was able to raise their curiosity, and felt that the teacher was willing to become involved with answering their questions and with showing interest in their interests. Other important factors related to greater interest and self-concept levels were advance organizers and the ability of the teacher to connect the science topic to student experiences. Perhaps female biology teachers felt more comfortable and more enthusiastic about their subject than did female chemistry or physics teachers.

The larger proportion of females teachers in the area of biology may also provide a partial explanation. Kanter (1978) has reported that people feel more comfortable in a situation, more empowered and less like a token, once a large enough proportion of similar people are in the same situation. Another factor likely to influence the biology outcome is that since female biology teachers read science journals and belong to professional organizations, they may feel more confident with their knowledge. The fact that male biology teachers spend more time teaching subjects other than biology may indicate that biology is not their first love. They may communicate a lack of enthusiasm to the students in subtle ways.

Manipulative Process Tests

In our process test results, we feel we have uncovered a possible path to encouraging girls in science. A manipulative process test was administered to both fifth and ninth grade students. According to some of the literature, girls do not do well in manipulative or discovery-type tasks (Harding, 1973); however, other research supports the opposite hypothesis. Johnson & Murphy (1986) have discussed their own Assessment of Performance Unit (APU) findings related to the superior process skills of girls, and also described similar findings by the British Columbia Science Assessment in 1979.

In the U.S., we were pleased to find evidence supporting the hypothesis that girls do excel in manipulative process tasks. For fifth grade students there was no significant difference between boys' and girls' scores on either subtest. At the ninth grade level, there was a 3% difference favoring boys on one subtest and no difference on the other subtest. The items with the greatest difference favoring boys were two items (one at each grade level) concerning bulbs and batteries, and one item requiring the calculation of mass, density, and volume. Girls achieved higher than did boys on an item requiring the planning of an experiment to test seeds for oil content, and on an item dealing with paper chromatography. It has been reported internationally (Johnson & Murphy,

1986) that boys outscore girls on items dealing with electricity. Johnson and Murphy also found that girls in Great Britain did better than boys on items involving chromatography. Table 4 is a comparison of the results of the achievement tests with the results of the process tests.

Perhaps process skills are not quite so sex-role stereotyped as is content. In standardized achievement tests, it may not be the intelligence of girls that is being assessed, but merely their ability to recall facts which they (in many cases) consider boring and/or useless in terms of future education or career goals. Since socialization plays an important part in defining sex-roles (Baker, 1980), and girls are able to perceive the expectations of others in their environment (Bornstein, 1982; Sadker & Sadker, 1982), they may realize that their parents, teachers, guidance counselors, and peers feel they either should or should not participate in certain courses. In fact, it has been hypothesized that there is subtle pressure against girls in science all through elementary and junior high school (Lipkin & Sadker, 1982). It may be that not much effort is made by teachers to entice girls into finding science interesting and enjoyable (Dickson, 1986). The "hidden curriculum" of the classroom (Bornstein, 1982) places girls in an insulated class-within-a-class. Perhaps then, girls are differentially eased out of the fun part of science, such as laboratory experiences. They might tend, therefore, to fall back on what they have always learned is appropriate classroom activity for females--- studying textbook facts. This could put them at a disadvantage since they would have an insufficient foundation of practical experience on which to base the facts they have memorized.

The manipulative process testing allowed girls to participate in the fun part of science. They were tested individually so no boy could take over the experiment or tell them they are doing something wrong. Girls may have felt freer to indulge in risk-taking when no one else was ready to pounce on their mistakes. Teaching science via process tasks may also be the way to encourage girls to study science. This does not mean continuance of present-day laboratories, but rather individual exercises in observation, recording data, stating of hypotheses, etc., with no right or wrong answers to be looked up in the back of the book.

Further research is necessary both in the area of manipulative tasks and in the area of written process tests. Five other countries have tested students on similar process tasks. Once their data have been analyzed we will be able to see if the trend of equal achievement of girls and boys on process skills holds true on an international

scale. We may find that teaching science in an integrated, process-oriented manner is, indeed, the more equitable method being searched for by many researchers in the field.

U.S. Sex Differences in an International Context

Almost two dozen countries were involved in the SISS. Not all of the data have been analyzed, but enough countries have turned in preliminary reports to enable us to make some international comparisons. We must be careful, however, not to assume that all international achievement scores are comparable. The populations differ from nation to nation. In England, for example, 'A' level students took (and did better on) the same tests as our advanced science students. One must realize, however, that the English students are truly science specialists, and most had been studying primarily science and math the entire time they were in secondary school. While we should be able, therefore, to safely compare scores of girls and boys within a country, we should not blithely compare scores between countries. Table 5 presents the sex differences in science achievement for those countries and/or populations that have completed analyzing their data. The differences are given as standard score differences.

It is disheartening to find that sex differences not only exist at all grade levels, but also that these differences exist in every nation involved in the SISS. Not all countries tested students at all population-levels. Out of the reporting countries, 15 tested at Grade 5. The U.S. had the fourth largest sex difference. All reporting countries tested at the ninth grade level. The U.S. tied with Norway and Singapore, having the third greatest sex difference. For the nine countries testing at the Grade 12 (non-science) population, the U.S. had the smallest sex difference. Singapore was the only other nation to even come close. The sex differences in the remaining seven countries were about twice as great (or greater) than those of the U.S.

Thirteen countries tested the specialty science populations. Some countries, such as Sweden, had different types of students taking the same tests. As an example, Sweden administered the physics test to both natural science majors and technical science majors. The biology instrument was given to both natural science majors as well as to health majors. Other countries may have had other types of population divisions. The standard score differences in Table 5 are the mean differences found on each test instrument. The only exception to this is the U.S., where first-year and advanced science students have their differences reported separately. The test instruments administered to the U.S. advanced science populations are largely identical to those used

by the other nations. The first-year science instruments are modified versions. It is of interest to note the differences in the first-year sciences, but for comparison purposes, we will confine our discussion to the advanced science populations.

Biology was the only area where some girls did as well as or better than boys. The mean effect size was .19. Australia, Hong Kong, and Sweden had small sex differences favoring females. There were also a number of countries which had minimal differences favoring males (an effect size of less than .25): England, Finland, Hungary, Japan, and Poland. The remaining five countries (including the U.S. which ranked fourth highest) had differences ranging from .28 (Canada) to .49 (Singapore).

Chemistry had a mean effect size of .36, twice that of biology. No nations had sex differences favoring girls in chemistry. The countries with the smallest differences favoring boys were Sweden (.04) and Italy (.12). All other countries had effect sizes ranging from .24 (Hong Kong) to .70 (Hungary). The U.S. tied with Finland for the fourth largest difference.

The mean sex difference in physics was slightly worse than in chemistry (.39). The only country with no significant difference was England, with an effect size of .04. Australia (.24) ranked next, but other than these two nations, no one had an effect size smaller than .25. The differences ranged as high as .59 (Poland). The U.S. had the fifth greatest difference in physics.

In the U.S., as in most other countries, differences were smallest in biology and greatest in physics and chemistry. There are researchers who say this is to be expected because biology is labelled "feminine," and, therefore, it is acceptable for girls to do well in it. A counter-argument, however, is that select populations, such as those taking advanced science, should have <u>smaller</u> sex differences than a more general population.

The U.S. advanced biology population was 59% female, the advanced chemistry was 44% female, and the advanced physics was only 21% female. It would be expected, at least for the physics population, that the mean scores of the girls would be more positively skewed than those of the boys. This was not found to be the case. For all populations tested, the distribution of scores for girls and boys remained similar, with boys always slightly higher than girls.

In England, where the proportion of girls in the physics population was small, no sex difference was found. This has been interpreted to mean that the female population is

so select, only the highest achieving girls are enrolled (Keys, 1986). Sex differences were found for both the biology and chemistry populations, in which the percentages of females were greater. England, however, was the only country in which this phenomenon occured in physics.

Sweden had no significant sex difference in chemistry, but they did have a difference (.23) favoring girls in biology, and a rather substantial difference (.39) favoring boys in physics. Italy was the only nation reporting no significant sex difference in chemistry while having differences favoring boys in biology (.39) and physics (.32).

As stated earlier, these are preliminary data from the majority of countries testing in the SISS. Further evaluation is necessary, as is an analysis of the international manipulative process test results. It may prove interesting to compare the results of the home and school background variables, as well as the attitude variables between nations. Do the female physics students in England come from different backgrounds or hold different opinions about science than females in other countries? Do female chemistry and biology students in Sweden have different backgrounds or attitudes than other girls?

Conclusions

The importance of this survey lies in the fact that it gives us the ability to make comparisons among almost two dozen nations. One problem of such a wide-scale survey is that the organization and coordination takes an extraordinary length of time and effort. Then, once data collection is completed, analysts find differences have still unwittingly crept in: Translations are not exact, printing processes vary, typographic errors appear even after innumerable proofreadings. The definitions of sample populations may also differ slightly, since no matter how carefully they are chosen, educational systems vary from country to country. All of these problems, however, should not detract from the vast amount of information that can be gleaned from such a survey. The national data alone may be worth the effort; and, as long as care is taken to correctly identify similarities and differences, many international comparisons can be safely made. In terms of sex differences in science achievement, we are given the opportunity to look at how certain factors influence the presence and magnitude of the differences: single-sex vs. mixed-sex schools, female vs. male teachers, centralized vs. decentralized school systems, and tracking vs. generalized curricula to name a few.

Although the preliminary international results may not be as encouraging as hoped for (in that there was no nation in which females did as well as males in all areas), many countries did have smaller sex differences than the U.S., and looking at these systems in greater detail may give us a push in the right direction. And we are not limited to the information from the achievement tests themselves. We also have data from attitude opinionnaires, home and school background variable questionnaires, and teacher questionnaires. A wealth of data is available, and the analyses have only begun.

TABLE 1
SAMPLE POPULATIONS

POPULATION	TOTAL	GIRLS	BOYS	NOT SPECIFIED
GRADE 5	2839	1426 (50.2%)	1372 (48.3%)	41 (1.4%)
GRADE 9	2519	1204 (47.8%)	1301 (51.6%)	14 (0.6%)
GRADE 12	2055	1131 (55.0%)	890 (43.3%)	34 (1.6%)
BIOLOGY 1	2582	1321 (51.2%)	1148 (44.5%)	113 (4.4%)
CHEMISTRY 1	2344	1091 (46.5%)	1201 (51.2%)	52 (2.2%)
PHYSICS 1	2719	997 (36.7%)	1687 (62.1%)	34 (1.3%)
BIOLOGY 2	659	369 (56.0%)	262 (39.8%)	28 (4.2%)
CHEMISTRY 2	552	231 (41.8%)	299 (54.2%)	22 (4.0%)
PHYSICS 2	485	101 (20.9%)	372 (76.7%)	12 (2.5%)

TABLE 2
PERCENTAGE OF EACH SEX SCORING CORRECTLY

POPULATION	GIRLS	BOYS	DIFFERENCE
GRADE 5	52.6%	57.9%	5.3%
GRADE 9	52.1%	58.4%	6.3%
GRADE 12 (NON-SCI)	45.0%	48.7%	3.7%
BIOLOGY 1	41.3%	44.3%	3.0%
CHEMISTRY 1	43.3%	48.7%	5.4%
PHYSICS 1	30.6%	36.0%	5.4%
BIOLOGY 2	40.3%	45.3%	5.0%
CHEMISTRY 2	33.0%	40.0%	7.0%
PHYSICS 2	40.3%	47.7%	7.4%

TABLE 3
MEAN SCORES OF STUDENTS BY SEX OF TEACHER

STUDENTS		TEACHERS	
		FEMALE	MALE
GRADE 5			
(24 ITEMS)	GIRLS	12.7 (4.41)	12.6 (4.56)
	BOYS	13.9 (4.62)	14.1 (4.62)
GRADE9			
(30 ITEMS)	GIRLS	15.1 (4.89)	15.9 (4.47)
	BOYS	17.3 (4.93)	17.7 (5.30)
BIOLOGY1			
(30 ITEMS)	GIRLS	12.8 (4.84)	12.4 (4.41)
	BOYS	14.2 (5.41)	13.0 (5.24)
BIOLOGY2			
(30 ITEMS)	GIRLS	12.6 (4.96)	11.6 (4.04)
	BOYS	14.9 (5.01)	12.8 (5.51)
CHEMISTRY1			
(30 ITEMS)	GIRLS	13.0 (3.94)	13.1 (4.26)
	BOYS	14.6 (4.10)	14.6 (4.82)
CHEMISTRY2			
(30 ITEMS)	GIRLS	10.0 (2.90)	10.8 (5.46)
	BOYS	11.4 (3.96)	12.8 (5.99)
PHYSICS1			
(35 ITEMS)	GIRLS	9.9 (3.22)	11.1 (4.22)
	BOYS	11.4 (3.96)	12.8 (4.67)

TABLE 4
COMPARISON OF RESULTS OF PROCESS AND ACHIEVEMENT TESTS

	PROCESS TEST (A)	PROCESS TEST (B)	ACHIEVEMENT TEST
GRADE 5			
BOYS	61.3%	48.3%	57.9%
GIRLS	60.0%	50.0%	52.6%
DIFFERENCE	1.3%	-1.7%	5.3%
GRADE 9			
BOYS	56.3%	50.0%	58.4%
GIRLS	53.1%	48.8%	52.1%
DIFFERENCE	3.2%	1.2%	6.3%

TABLE 5
INTERNATIONAL SCIENCE ACHIEVEMENT
(standard score differences)

	GR5	GR9	GR12*	BIOL	CHEM	PHYS
AUSTRALIA	.27	.28	.27	-.02	.48	.24
CANADA (ENG)	.22	.38	.25	.28	.40	.43
ENGLAND	.20	.36	.28	.19	.32	.04
FINLAND	.31	.29	--	.19	.42	.50
HONGKONG	.19	.37	--	-.18	.24	.45
HUNGARY	.15	.14	.32	.18	.70	.40
ISRAEL	--	.49	--	--	--	--
ITALY	.17	.31	.51	.39	.12	.32
JAPAN	.06	.31	.42	.20	.34	.30
KOREA	.33	.41	--	--	--	--
NETHERLANDS	--	.49	--	--	--	--
NORWAY	.44	.39	.47	.44	.41	.38
PHILIPPINES	.04	.17	--	--	--	--
POLAND	.24	.33	--	.17	.44	.59
SINGAPORE	.27	.39	.18	.49	.41	.47
SWEDEN	.24	.38	--	-.23	.04	.39
THAILAND	--	.34	--	--	--	--
U.S.A.(ADVANCED)	.29	.39	.14	.33	.42	.44
(1ST YEAR)	__	__	__	.18	.36	.44
MEAN:	**.23**	**.35**	**.32**	**.19**	**.36**	**.39**

Israeli results from Levin, Sabar, & Libman, 1987; results of other nations from Science Achievement in 17 Countries. IEA, 1988. *Non-science population

References

Aiken, L.R. & Aiken, D.R. (1969). Recent research on attitudes concerning science. Science Education, 53, 295-305.

Backman, M.E. (1971). Patterns of mental abilities: Ethnic, socioeconomic, and sex differences. American /Educational Research Journal, 9, 1-12.

Baker, S. W. (1980). Biological influences on human sex and gender. Journal of Women in Culture and Society, 6, 80-96.

Baumel, H.B. & Berger, J.J. (1965). An attempt to measure science attitudes. Science Education, 49, 267-269.

Bornstein, R. (1982). Sexism in education. In M.P. Sadker & D.M. Sadker (Eds.), Sex equity handbook for schools. New York: Longman, Inc.

Comber, L.C. & Keeves, J. P. (1973). Science education in nineteen countries. International studies in evaluation I. New York: Halsted Press.

Dickson, D. (1986). Britain's Royal Society condemns sex bias in mathematics teaching. Science, 233, 618-619.

Haertel, G. D., Walberg, H. J., Junker, L., & Pascarella, E. T. (1981). Early adolescent sex differences in science learning: Evidence from the National Assessment of Educational Progress. American Educational Research Journal, 18, 329-341.

Harding, J. (1973). What has Nuffield done for girls? Times Education Supplement, 30 November.

Hoffmann, L. (1987). The significance of school and out-of-school conditions in the development of male and female students' interest: The example of physics. Contributions to the Fourth GASAT Conference. Vol. 3, 95-102. University of Michigan, Ann Arbor, 24-29 July.

International Association for the Evaluation of Educational Achievement. (1988). Science achievement in seventeen countries. A preliminary report. Elmsford, NY: Pergmon Press.

Johnson, S. & Murphy, P. (1986). Girls and physics. Reflections on APU survey findings. Occasional Paper 4. London: Department of Education and Science.

Kahle, J.B., Matyas, M.L., & Cho, H.H. (1985). An assessment of the impact of science experiences on the career choices of male and female biology students. Journal of Research in Science Teaching, 22, 385-394.

Kanter, R.M. (1977). Men and women of the corporation. NY: Basic Books.

Keeves. J.P. (1973). Differences between the sexes in mathematics and science courses. International Review of Education, 19, 47-64.

Keys, W. (1986). The Second IEA Science Study: Aspects of science education in English schools. Slough, England: NFER.

Levin, T., Sabar, N., & Libman, Z. (1987). Girls' understanding of science: A problem of cognitive or affective readiness? Contributions to the Fourth GASAT Conference, Vol. 2, 104-112. University of Michigan, Ann Arbor, 24-29 July.

Lipkin, J. & Sadker, D. (1982). The report card #3: Sex bias in mathematics, computer science and technology. Washington, D.C.: The Mid-Atlantic Center for Sex Equity.

Sadker, M.P. & Sadker, D.M. (1982). Sex equity handbook for schools. New York: Longman.

Simpson, R.D. (1978). Relating student feelings to achievement in science. In M.B. Rowe (ed.), What research says to the science teacher, Vol. 1. Washington, DC: National Science Teachers' Association, 40-54.

Steinkamp, M. W. & Maehr, M. L. (1984, Spring). Gender differences in motivational orientations toward achievement in school science: A quantitative synthesis. American Educational Research Journal, 21, 39-59.

Vestin, M. (1975). Some information concerning sex role question and programs for development of equality between men and women especially within school and education. Stockholm: Swedish National Board of Education.

Welch, W.W. & Lawrenz, F. (1982). Characteristics of male and female science teachers. Journal of Research in Science Teaching, 19, 587-594.

Wolf, R. M. (1977). Achievement in America. New York: Teachers College Press.

Zerega, M. E., Haertel, G. D., Tsai, S., and Walberg, H. J. (1986). Late adolescent sex differences in science learning. Science Education, 70, 447-460.